

MORPHOMETRIC RELATIONSHIPS IN TROPICAL ANURANS AND THEIR RELATIONSHIP TO SOME LIFE HISTORY PARAMETERS¹

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(With one text-figure)

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Morphometric relationships between snout-vent length (SVL), femur length (FL), body weight (BW) and gonad weight (GW) of two terrestrial, three terrestrial burrowing, one arboreal, one aquatic swimming and two semi-aquatic jumping anuran species collected from five different habitats show that the ratio of body mass of female : male is highest (2.6) in aquatic species and lowest (1.053-1.287) in the terrestrial burrowing species. In semi-aquatic (1.553-1.616) and arboreal species (1.784) this ratio lies in between these two extreme values. The SVL was approximately 2.4, 2.0 and less than 2.0 times larger than the femur length in terrestrial and terrestrial burrowing species, in aquatic and semi-aquatic anurans and in arboreal species respectively. Significant sexual dimorphism, except in the burrowing species, with regard to body mass and other parameters were observed. The gonad development is a function of body size and is sex specific. The amplex adult weight is sex specific. Morphometric features appear to be correlated to habitat requirement of each species.

INTRODUCTION

Although India has a very rich fauna of amphibians (Inger and Dutta, 1987; Das, 1996), extensive quantitative ecological studies have not been made on the amphibian communities in the Indian ecosystems except for the recent work of Dash and Mahanta (1993). The different morphological parameters, like total body length (snout to vent), femur length, body weight, gonad weight are indices of growth and development in the amphibians. The growth and development processes are sequential and usually proportionate (Mahapatro and Dash 1991). Hence a proportionate relationship among the various growth parameters like snout-vent length (SVL), femur length (FL), body weight (BW) and gonad weight (GW) etc. is theoretically expected.

We wanted to examine if these relationships are species-specific, functions of some life history parameters and based on their habitat

requirements. The present study involving 15 months of field work also covered the morphometry of nine anuran species i.e. *Bufo melanostictus*, *B. stomaticus*, *Microhyla ornata*, *Ramanella variegata*, *Polypedates maculatus*, *Euphlyctis cyanophlyctis*, *Limnonectes limnocharis*, *Hoplobatrachus tigerinus*, and *Tomopterna rolandae* collected from five different habitats. Dutta *et al.* (1991) made size analysis and reported the sex ratio of *Hoplobatrachus crassus*. Mohanty-Hejmadi (1974) provides information on the range of snout-vent length, and femur length of 11 anuran species (mature individuals of 10 species and juvenile individuals of 2 species) but does not answer the questions we have examined.

MATERIAL AND METHODS

Study sites

The study sites consisted of 500 acres of irrigated and unirrigated paddy fields, 20 acres of natural hill forest and two human habitation

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sites (one urban 300 acres and one rural 500 acres of Larambha village area) in the Sambalpur district of Orissa. The maximum, minimum and mean temperature of 15 months (October 1990 to December 1991) was 33.9°C, 17.9°C and 24.9°C respectively. The total rainfall during the study period was 1528.9 mm and maximum rainfall of 537.9 mm was recorded in July. The mean relative humidity was 65.7% (range: 48.3 to 84.6%).

The detailed descriptions of the study sites and sampling methods have been reported in Dash and Mahanta (1993). Adult and immature anurans were collected by stratified transect sampling and brought to the laboratory for morphometric measurements and identification of sex, and then the animals were released near the sampling plots (using the methods of Crump 1971, Heyer 1973, Daniel 1963, 1975). Sampling sizes varied as the relative density and availability of species during the sampling time was not constant. On some occasions, animals had to be sacrificed to note the development of gonads. The snout-vent length, femur length were measured by calipers and the weight was measured by chemometric balance (± 1 mg).

Morphometric relationships were analysed by regression and correlation analysis (Snedecor and Cochran 1967).

Definition of some terms used:

- (a) Snout-vent length (SVL): The length (mm) from snout to vent.
- (b) Femur length (FL): The length from vent to end of femur.
- (c) Gonad development: After dissection the development of gonad was observed under a magnifying glass and dissecting microscope.
- (d) Minimum amplex size: The smallest male and female size observed in amplexus.
- (e) Life history groups: The species were grouped according to their habits and ecological adaptations, as follows:

- (i) Terrestrial: *Bufo melanostictus*, *B. stomaticus*.
- (ii) Terrestrial burrowing: *Microhyla ornata*, *Ramanella variegata*, *Tomopterna rolandae*.
- (iii) Arboreal: *Polypedates maculatus*.
- (iv) Semi-aquatic jumping: *Limnonectes limnocharis*, *Hoplobatrachus tigerinus*.
- (v) Aquatic Swimming: *Euphlyctis cyanophlyctis*.

RESULTS AND DISCUSSION

Morphometric measurements:

Measurement of parameters like snout-vent length (SVL), femur length (FL), body weight (BW), gonad weight (GW) of nine tropical anuran species indicate that the mature female in all species has a larger body mass than the mature male, showing distinct sexual dimorphism. The highest ratios of SVL of female : male is 1.45 and body mass of female : male is 2.60 in *Euphlyctis cyanophlyctis*, an aquatic swimming species. The ratios are lowest in the terrestrial burrowing species irrespective of their body sizes (Table 1 & 2) (SVL ratio 1.067 ± 0.036 and BW ratio 1.145 ± 0.125). In semi-aquatic species which make big jumps, the SVL ratio is 1.181 ± 0.008 and body weight ratio is 1.584 ± 0.044 . In *Bufo* species (complete terrestrial) the SVL ratio is 1.079 ± 0.048 and BW ratio is 1.401 ± 0.182 . These data support the view that female anurans are typically larger than their male counterparts (Crump 1974, Shine 1979, Mahapatro and Dash 1991) but in some burrowing species (*Microhyla ornata* and *Ramanella variegata*) there is no statistically significant difference in adult male and female body size (Table 1).

The SVL is found to be 2.383 ± 0.18 and 2.548 ± 0.212 times larger than in terrestrial and terrestrial burrowing species respectively. The ratio of SVL to FL is lowest (1.82 ± 0.026) in the arboreal species. This ratio is 1.962 ± 0.033 in aquatic swimming species and 1.944 ± 0.12 in

TABLE 1
RELATIONSHIP IN THE BODY WEIGHT OF MALE AND FEMALE ANURANS

Habits	Species	Average Body Weight (g) \pm SD		Body Weight Ratio	
		Male	Female	't' value	Female / Male
Terrestrial	<i>Bufo melanostictus</i>	41.374 \pm 12.054 (50)	63.309 \pm 23.024 (77)	6.194	1.530
	<i>Bufo stomaticus</i>	27.650 \pm 2.694 (16)	35.20 \pm 6.840 (17)	2.60	1.273
Terrestrial burrowing	<i>Microhyla ornata</i>	0.933 \pm 0.259 (18)	0.983 \pm 0.314 (09)	0.545*	1.053
	<i>Ramanella variegata</i>	1.570 \pm 0.420 (13)	1.720 \pm 0.380 (14)	1.22	1.095
	<i>Tomopterna rolandae</i>	3.635 \pm 0.515 (20)	4.680 \pm 0.730 (25)	5.408	1.285
Arboreal	<i>Polypedates maculatus</i>	5.960 \pm 1.137 (05)	10.632 \pm 2.872 (17)	3.508	1.784
Semi-aquatic jumping	<i>Limnonectes limnocharis</i>	1.731 \pm 0.346 (236)	2.688 \pm 0.532 (370)	24.495	1.553
	<i>Hoplobatrachus tigerinus</i>	225.000 \pm 77.780 (02)	363.750 \pm 38.670 (10)	4.057	1.616
Aquatic swimming	<i>Euphlyctis cyanophlyctis</i>	4.900 \pm 1.312 (57)	12.740 \pm 2.383 (36)	20.458	2.600

Number in parentheses indicates the sample size.

* Difference is not statistically significant.

semi-aquatic jumping species (Table 3). These values do not differ significantly between male and female and size groups (mature males, mature females and immatures) (Table 3, Fig. 1).

Considering the SVL/FL length in different ecological groups of amphibians, we interpret that since the arboreal species make long strides (jumps) from tree to tree and place to place, the body weight and SVL should be such that it does not put a lot of pressure on the femur for jumping purpose. Hence the ratio is minimum in *Polypedates maculatus* in comparison to other groups. The semi-aquatic and aquatic species not only swim very fast but also often jump from the banks to the water and hence a larger body weight/SVL would be disadvantageous. Their SVL/FL ratio varies between 1.859 to 2.023 which is close

to the arboreal species. The terrestrial surface dwelling and terrestrial burrowing species do not make long strides; they move slowly and hence a large body weight or a larger SVL is not disadvantageous to them. Besides, a large body size would be advantageous to repel smaller predators.

Irrespective of the habitats, significant positive correlation exists in the adult anurans between the values of SVL and FL, SVL and BW (log values) SVL and GW, FL and BW (log values), BW and GW. In *Bufo melanostictus*, gonad development starts when SVL is 40 mm and the corresponding average BW is 6.92 + 1.285 g. The amplex adult weight is sex specific. The amplexing males have a minimum SVL of 61 mm and corresponding average BW 26.83 +

TABLE 2
RELATIONSHIP IN THE SVL OF MALE AND FEMALE ANURANS

Habits	Species	Average SVL mm \pm SD		't' value	SVL Ratio Female / Male
		Male	Female		
Terrestrial	<i>Bufo melanostictus</i>	70.74 \pm 6.38 (50)	78.77 \pm 7.88 (77)	16.987	1.135
	<i>Bufo stomaticus</i>	59.96 \pm 3.50 (16)	62.70 \pm 2.78 (17)	3.358	1.045
Terrestrial burrowing	<i>Microhyla ornata</i>	19.16 \pm 1.42 (18)	20.66 \pm 1.12 (09)	3.191	1.078
	<i>Ramanella variegata</i>	24.15 \pm 2.20 (13)	24.80 \pm 2.10 (14)	1.151*	1.027
	<i>Tomopterna rolandae</i>	29.20 \pm 1.19 (20)	32.00 \pm 1.00 (25)	8.964	1.096
Arboreal	<i>Polypedates maculatus</i>	42.60 \pm 3.13 (05)	50.70 \pm 4.18 (17)	7.990	1.190
Semi-aquatic jumping	<i>Limnonectes limnocharis</i>	24.18 \pm 1.10 (236)	28.71 \pm 1.73 (370)	36.618	1.022
	<i>Hoplobatrachus tigerinus</i>	114.50 \pm 9.50 (02)	134.50 \pm 7.14 (10)	9.507	1.175
Aquatic swimming	<i>Euphlyctis cyanophlyctis</i>	34.96 \pm 2.61 (57)	50.75 \pm 2.90 (36)	44.976	1.452

Number in parentheses indicates the sample size.

* Difference is not statistically significant.

1.44 g. Amplecting females have a minimum SVL 66 mm and corresponding average BW 28.83 ± 6.525 g. In *Bufo stomaticus* the gonad development starts when the SVL is 35 mm and the average BW is 5.825 ± 0.377 g. The amplecting males have a minimum SVL 58 mm with corresponding BW of 28.4 ± 1.277 g. In *Euphlyctis cyanophlyctis* development of gonad starts when SVL is 25 mm and the corresponding average BW is 1.84 ± 0.255 g. The amplecting males have a minimum SVL of 46 mm with average BW of 10.867 ± 0.416 g. In *Limnonectes limnocharis* the SVL value is 20 mm and the corresponding average BW value is 1.064 ± 0.134 at the time of gonad development. The amplecting males have a minimum SVL 23 mm with average BW 1.454 ± 0.237 g. The amplecting females have a minimum SVL 27 mm with

corresponding BW of 2.175 ± 0.323 g (Table 4).

Data on the gonad development of other species are not available. The amplecting males have the minimum SVL of 16 mm, 40 mm, 20 mm, 105 mm, 28 mm and corresponding average BW 0.600 g, 5.65 ± 1.343 g, 1.3 ± 0.141 g, 170.0 g, 3.275 ± 0.266 g in *Microhyla ornata*, *Polypedates maculatus*, *Ramanella variegata*, *Hoplobatrachus tigerinus*, and *Tomopterna rolandae*. The amplecting females have the minimum SVL of 19 mm, 45 mm, 22 mm, 125 mm, 31 mm and corresponding average BW of 0.7 g, 7.267 ± 1.040 g, 1.3 g, 320.25 ± 0.353 g, 4.025 ± 0.594 g in *Microhyla ornata*, *Polypedates maculatus*, *Ramanella variegata*, *Hoplobatrachus tigerinus* and *Tomopterna rolandae* (Table 4).

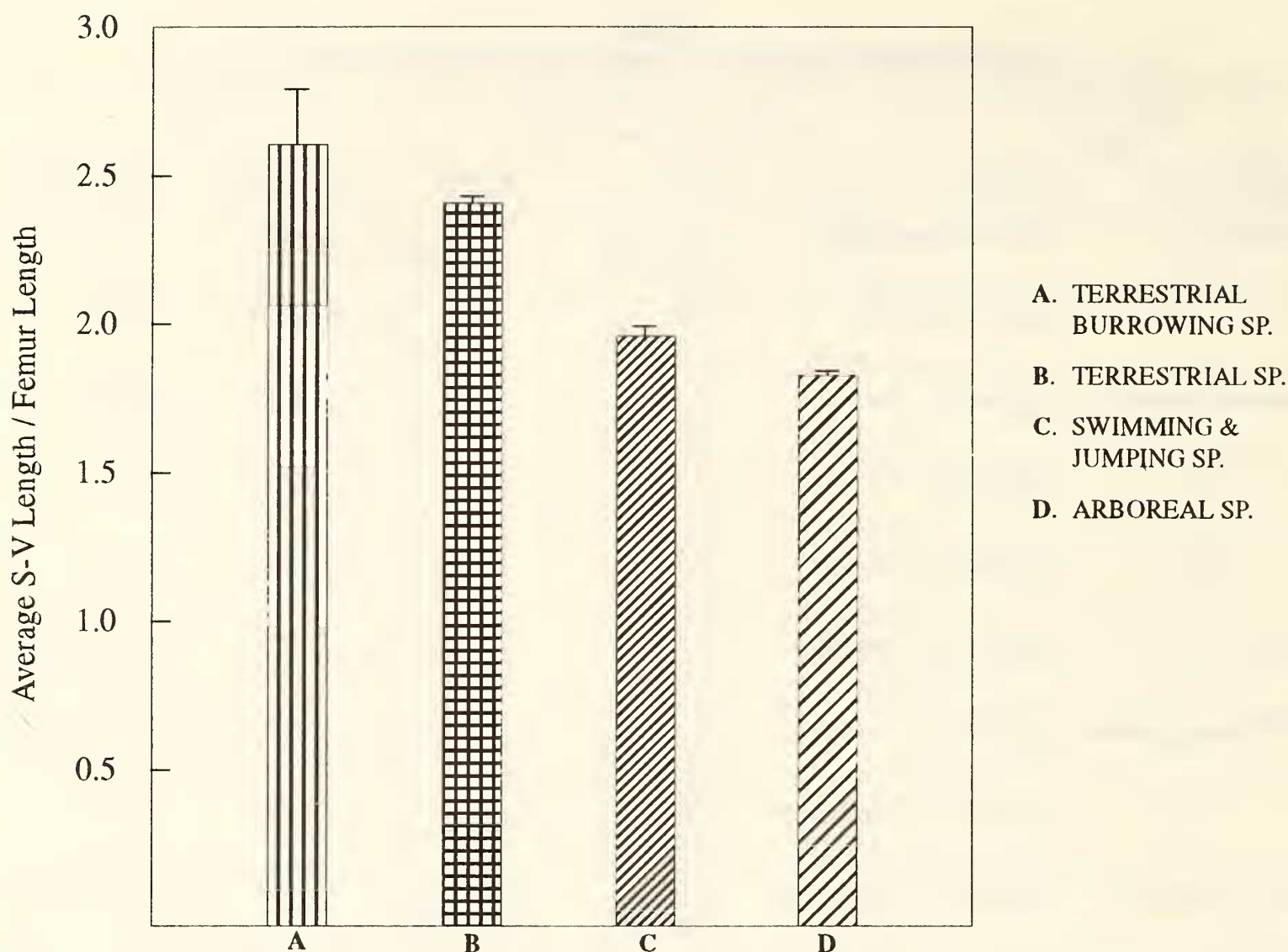


Fig. 1. Ratio of average S-V length/femur length in four groups of tropical anurans with different mode of living

CONCLUSION

A review of literature indicates that generalisation based on morphometric relationships, life history parameters and habits in anurans have not been made earlier. This generalisation indicates a distinct trend in the ratio of SVL and FL in different groups of anurans with different habitats (terrestrial, arboreal, terrestrial burrowing, aquatic swimming and semi-aquatic jumping etc.). The work also provides field data on the body size at gonad development and of amplexing adults of nine tropical anuran species. The data indicates that ecological groupings of amphibians like terrestrial, terrestrial burrowing, arboreal, aquatic swimming and semi-aquatic jumping, etc. are an added value to pure taxonomic classification.

TABLE 3
RELATIONSHIP OF THE SNOUT-VENT LENGTH (SVL) AND FEMUR LENGTH (FL) OF NINE ANURAN SPECIES

Habit	Species	SVL/FL		
		Male	Female	Immature
Terrestrial	<i>Bufo melanostictus</i>	2.359	2.389	2.44
	<i>Bufo stomaticus</i>	2.320	2.379	2.41
Terrestrial burrowing	<i>Microhyla ornata</i>	2.63	3.20	2.46
	<i>Ramanella variegata</i>	2.616	2.58	2.47
	<i>Tomopterna rolandae</i>	2.30	2.33	2.354
Arboreal	<i>Polypedates maculatus</i>	1.85	1.81	1.80
Semi-aquatic jumping	<i>Limnonectes limnocharis</i>	2.02	2.02	2.03
	<i>Hoplobatrachus tigerinus</i>	1.76	1.847	1.971
Aquatic swimming	<i>Euphlyctis cyanophlyctis</i>	1.946	2.00	1.94

* sample size is given in Table 4

TABLE 4
RELATIONSHIP OF SNOUT-VENT LENGTH AND BODY WEIGHT WITH GONAD DEVELOPMENT AND
MINIMUM AMPLEX ADULT SNOUT-VENT LENGTH

Habit	Species	Start of gonad development		Sex	Minimum SVL (mm) (for amplex adult)	Average BW (g) \pm SD (Range in parentheses)
		Minimum SVL (mm)	Average BW (g) \pm SD			
1	2	3	4	5	6	7.
Terrestrial	<i>Bufo melanostictus</i>	40	6.925 \pm 1.285 (8)	M	61	26.83 \pm 1.44 (26.00-28.50) (3)
				F	66	28.83 \pm 6.52 (22.00-35.00) (3)
	<i>Bufo stomaticus</i>	35	5.825 \pm 0.377 (4)	M	55	23.00 (1)
				F	58	28.40 \pm 1.27 (27.00-29.50) (3)
Terrestrial Burrowing	<i>Microhyla ornata</i>	—	—	M	16	0.60 (1)
				F	19	0.70 (1)
	<i>Ramanella variegata</i>	—	—	M	20	1.30 \pm 0.14 (2) (1.20-1.40) (2)
				F	22	1.30 (2)
	<i>Tomopterna rolandae</i>	—	—	M	28	3.27 \pm 0.26 (2.80-3.60) (8)
				F	31	4.02 \pm 0.59 (3.00-4.60) (8)
Arboreal	<i>Polypedates maculatus</i>	—	—	M	40	5.65 \pm 1.34 (4.70-6.60) (2)
				F	45	7.26 \pm 1.04 (6.10-8.10) (3)
Semi-aquatic Jumping	<i>Limnonectes limnocharis</i>	20	1.06 \pm 0.13 (22)	M	23	1.45 \pm 0.23 (0.92-1.70) (18)
				F	27	2.17 \pm 0.32 (1.50-2.70) (20)
	<i>Hoplobatrachus tigerinus</i>	—	—	M	105	170.00 (1)
				F	125	320.25 \pm 0.35 (320.00-320.50) (2)
Aquatic Swimming	<i>Euphlyctis cyanophlyctis</i>	25	1.84 \pm 0.255 (9)	M	33	3.87 \pm 0.38 (3.20-4.50) (18)
				F	46	10.86 \pm 0.41 (10.40-11.20) (3)

M — Male

F — Female

SVL — Snout-Vent Length

BW — Body weight

Numbers in parentheses indicate the sample size.

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